Lymphopenia Predicts Early Mortality in Cancer Patients with Sepsis, A Retrospective Study of Medical Records

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Research

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Abstract

Background: Postoperative sepsis in cancer patients becomes a major problem at present, but the efficiently prognostic biomarkers are limited. The present study was sought to evaluate the prognostic relevance of absolute lymphocyte counts (ALCs) in cancer patients with postoperative sepsis, which might help patients to get early treatment and improve their prognosis.

Methods: Retrospective study was conducted under 368 cancer patients with postoperative sepsis who were admitted in ICU of two Chinese tertiary care hospitals from January 1, 2016 to December 31, 2017. ALCs were daily collected during the first week after being enrolled in the study. The primary outcomes of the study included 28-day and 90-day mortalities, while the secondary outcomes were hospital and ICU length of stay.

Results: The absolute lymphocyte counts on day 3 were reduced in the survivors comparing with those in non-survivors. Statistically, the significantly decreased 28-day and 90-day survival rates were detected in the patients with severe and moderate lymphopenia, compared to those with no lymphopenia. These present results were consistently found and evidently confirmed in the two different hospitals.

Conclusions: In accordance with the day-4 lymphopenia prediction of sepsis diagnosis, this present study revealed that lymphopenia on the day 3 after the diagnosis of sepsis was able to predict the early mortality in postoperative cancer patients. Earlier monitoring and management of lymphopenia may be needed for cancer patients with postoperative sepsis.

Background

As a life-threatening organ dysfunction, sepsis possibly occurs in any patients with infection, especially in those with chronic illness and comorbidity[1, 2]. Treatments, such as mechanical ventilation, renal replacement therapy and fungal infection, increase the risk of sepsis[3]. Sepsis causes more than 5 million deaths worldwide, annually[4]. However, the mortality and morbidity of sepsis are higher among cancer patients than among general patients[5]. Cancer and the effects of its surgery (e.g., hormonal changes, hemorrhage and transfusion, occurrence of ischemia–reperfusion, and extent of surgical trauma) are critical to immunosuppression which mainly causes the higher mortality and morbidity[6].

Absolute lymphocyte counts (ALCs) are usually selected as a marker because it could reflect the infection and its rapid detection and low economic cost. ALCs play a significant role in immunosuppression and are associated with prognosis of both sepsis and tumors[7, 8]. ALCs < 1.0 cells/μL × 10^3 was defined as lymphopenia, which indicated that adaptive immune system was impaired[9, 10]. According to previous study, lymphopenia on the fourth day after diagnosis of sepsis was seen as a predictive marker for sepsis mortality[10]. The decreased ALCs were seen as a result of braking immune balance by strong systemic inflammatory response and anti-inflammatory process in sepsis, being responsible for worsening outcome in sepsis patients[10]. Additionally, lymphocytes are involved with anti-tumor immune responses and decreased ALCs service as a negatively predictive factor in cancer[11]. Lymphopenia plays a vital role

in the worse relapse-free survival and overall survival in patients with various kinds of tumors such as Non-Hodgkin's lymphoma, diffuse large B cell lymphoma, T-cell lymphomas, breast cancer, sarcomas and colon carcinoma [12–17]. Furthermore, anti-tumor immune system is weak during perioperative period[11]. Lymphopenia was reported as an independent risk factor for postoperative pneumonia after lung cancer surgery and peaked at postoperative day 1 after the surgery[18]. Therefore, there might be an association between ALCs and prognosis of postoperative sepsis patients with cancer. Moreover, the peak of lymphopenia might be earlier than that of general sepsis patients.

Postoperative sepsis in cancer patients becomes a major problem at present, but the efficiently prognostic biomarkers are limited. Consequently, the present study aimed to examine the predictive role of lymphopenia for mortality of postoperative sepsis patients with cancer, as well as to investigate the association between lymphopenia and hospital versus lymphopenia and ICU length of stay in the subjected patients.

Materials And Methods

Study setting and population

The medical records were retrospectively searched in the Harbin Medical University Cancer Hospital and the Affiliated Second Hospital of Harbin Medical University from January 1, 2015 to December 31, 2016. All subjects were fulfilled the criteria of sepsis or septic shock according to the Third International Consensus Definitions for Sepsis and Septic Shock (SEPSIS-3) [2]. Inclusion criteria included: (1) age ≥18 years old; (2) undergoing complete surgical resection and diagnosis of cancer was confirmed by histology; (3) diagnosis of sepsis in ICU. Exclusion criteria included: (1) pregnancy; (2) human immunodeficiency virus (HIV) infection; (3) neutropenia (< 500 neutrophils/mm^3); (4) medical treatment with steroid; (5) preoperative chemotherapy or radiation therapy; (6) incomplete medical records.

Written informed consents were obtained from all patients. This study was approved by the Institutional Review Board of the Harbin Medical University Cancer Hospital and the Affiliated Second Hospital of Harbin Medical University.

Data collection

Data about age, sex, body mass index (BMI), body temperature, respiratory rate, organism, infection site of origin, co-morbidities and venous blood laboratory tests were collected by a separate research assistant blinded to the study hypothesis, the patients' baseline characteristics, and outcomes. BMI was calculated as the ratio of weight (kg) to height squared (m^2). Daily clinical and laboratory data were gathered in the first 7 days after registration for the study. Day-1 was defined as the first 24-hour time period when patients were diagnosed with sepsis in ICU; while, the next 24-hour time period was determined as day-2, along with others. For patients with multiple venous blood laboratory or daily

physical examination in ICU, the worst data in 24-hour was assembled. Severe lymphopenia was defined as ALCs ≤ 0.5 cells/μL × 10^3; moderate lymphopenia was referred as counts of 0.5 to 1.0 cells/μL × 10^3; and no lymphopenia was identified as counts ≥ 1.0 cells/μL × 10^3. The reason for dividing lymphopenia patients into moderate and severe groups was to facilitate the observation of the grading changes in the outcomes associated with increasingly severe lymphopenia. The Acute Physiology and Chronic Health Evaluation (APACHE) II and the Sequential Organ Failure Assessment (SOFA) scores were determined[2, 19]. The infection site of origin was determined by the treating physician, according to the presence of concurrent cultures which grew the same organism from another site. The requirements for vasopressors and mechanical ventilation during the cancer surgery or ICU, and antibiotic usage in ICU were recorded. The coefficients of variation (CVs) of the inter- and intra-assays were below 5 %.

Outcomes

The primary outcomes of the study consisted of 28-day and 90-day mortalities, while the secondary outcomes were hospital and ICU length of stay.

Statistical analysis

All statistical analyses were performed using SPSS Statistics version 25.0 (SPSS Inc., Chicago, IL, USA). The database was divided into a development set and a validation set. The descriptive statistics were presented as means ± SD or medians (interquartile range) for continuous variables and percentages of the number for categorical variables. When baseline characteristics between two groups were compared, the normally distributed continuous variables were compared with the Student's t test and skewed-distributed with the Mann-Whitney U test. Three lymphopenia group comparisons were conducted using one-way ANOVA test. The Chi-square test was used for categorical variables. Survival curves were drawn using the Kaplan-Meier method, and the difference between two survival curves was evaluated using the log-rank test. Cox proportional hazards models were applied to explore the predictors of survival in univariate- and multivariable analyses. *P*-value < 0.05 was considered to indicate a statistically significant difference.

Results

The characteristics of the 368 patients were summarized in **Table 1**. In the development set, from the total of 240 patients, 144 (60.0%) survived until day 28 after ICU admission, whereas 96 (40.0%) patients did not. The abdomen was the most common source of infection, followed by lung infection. Non-survivors were presented with more severe disease, as reflected by higher APACHE II and SOFA scores, as well as higher lactate levels. The 28-day mortality occurred in 31.3% of patients in the ICU. There were no significant differences in age, sex, BMI, body temperature, respiratory rate, heart rate, coronary artery disease, chronic obstructive pulmonary disease (COPD), hypertension, and diabetes mellitus, between two

groups. However, blood lactate, APACHE II and SOFA scores, lengths of ICU and hospital stay in two groups showed significant differences. In the validation set, from the total of 128 patients, lactate levels, APACHE II score, SOFA score, and length of hospital stay displayed significant differences.

Variables	Non-survivors	Survivors	*p*-value
Development set			
N	96	144	
Age (years)	62.4±10.0	62.2±11.5	0.878
BMI (kg/m2)	22.4±3.5	22.8±3.2	0.308
Sex (male, %)	64 (66.7)	90 (62.5)	0.51
Body temperature (℃)	36.7 (36.4–37.0)	36.6 (36.4–37.0)	0.63
Respiratory rate (rate/min)	23 (19–30)	24 (19–31)	0.664
HR (bpm)	118±29	113±30	0.175
Lactate (mmol/L)	3.2 (1.5–6.0)	1.6 (1.0–3.0)	< 0.001
APACHE II score	18 (14–24)	17 (13–20)	0.001
SOFA score	9 (7–12)	8 (6–9)	<0.001
Infection site of origin, number (%)			
Lung	28 (29.2)	33 (22.9)	0.276
Abdomen	56 (58.3)	100 (69.4)	0.077
Urinary tract	6 (6.3)	4 (2.8)	0.187
Other	6 (6.3)	7 (4.9)	0.641
Organism, n (%)			
Gram-positive	28 (29.2)	40 (27.8)	0.815
Gram-negative	54 (56.3)	79 (54.9)	0.832
Mixed	8 (8.3)	15 (10.4)	0.591
Fungal	6 (6.3)	10 (6.9)	0.833
Comorbidities, n (%)			
Coronary artery disease	10 (10.4)	19 (13.2)	0.518
COPD	1 (1.0)	0 (0)	0.220
Hypertension	12 (12.5)	27 (18.8)	0.199
Diabetes mellitus	8 (8.3)	15 (10.4)	0.591
Length of ICU stay,	3 (1-5)	4 (2-7.8)	0.001

median (IQR)			
Length of hospital stay, median (IQR)	16.5 (8.0-22.8)	27.0 (18.0-36.0)	< 0.001
ICU mortality (%)	30 (31.3)	8 (5.6)	< 0.001
Validation set			
N	45	83	
Age (years)	67.7±10.1	66.4±10.3	0.488
BMI (kg/m2)	23.5±3.7	23.1±3.9	0.561
Sex (male, %)	29 (64.4)	59 (71.1)	0.439
Body temperature (℃)	36.7 (36.5–37.0)	36.8 (36.5–37.0)	0.281
Respiratory rate (rate/min)	16 (14–22)	16 (15–21)	0.607
HR (bpm)	97±35	96±26	0.9
Lactate (mmol/L)	2.4 (1.4–3.9)	1.7 (1.3–3.2)	0.022
APACHE II score	27 (24–30)	25 (23–27)	0.037
SOFA score	7 (6–10)	7 (5–8)	0.023
Infection site of origin, number (%)			
Lung	17 (37.8)	24 (28.9)	0.305
Abdomen	26 (57.8)	59 (71.1)	0.128
Urinary tract	1 (2.2)	0 (0)	0.173
Other	1 (2.2)	0 (0)	0.173
Organism, n (%)			
Gram-positive	10 (22.2)	21 (25.3)	0.698
Gram-negative	27 (60.0)	42 (50.6)	0.308
Mixed	4 (8.9)	11 (13.3)	0.464
Fungal	4 (8.9)	9 (10.8)	0.727
Comorbidities, n (%)			
Coronary artery disease	9 (20.0)	21 (25.3)	0.499
COPD	2 (4.4)	3 (3.6)	0.817
Hypertension	7 (15.6)	24 (28.9)	0.092

Diabetes mellitus	4 (8.9)	14 (16.9)	0.215
Length of ICU stay, median (IQR)	3 (1-5)	2 (1-2)	0.092
Length of hospital stay, median (IQR)	19.0 (15.5-24.0)	26.0 (19.0-36.0)	< 0.001
ICU mortality (%)	6 (13.3)	4 (4.8)	0.087

Table 1
Table 1 Baseline characteristics of patients stratified by 28-day survival status after admission.

Data are expressed as means (SD) or percentage. SD, standard deviation; BMI, body mass index; HR, heart rate; CEA, carcinoembryonic antigen; ICU, Intensive Care Unit; SOFA, Sepsis Related Organ Failure Assessment; APACHE, Acute Physiology and Chronic Health Evaluation; IQR, 25%, 75% interquartile range; COPD, chronic obstructive pulmonary disease.
The distributions of the white blood cell (WBC), ALCs, and absolute neutrophil count during the first four days after the diagnosis of sepsis between survivors and non-survivors were presented in Fig. 1. On day 1, the WBC and absolute neutrophil count levels were increased in the survivors comparing with those in non-survivors. However, there were no significant difference in ALCs between the survivors and non-survivors. On day 3, the ALCs were reduced in the non-survivors, comparing with those in the survivors (p = 0.003 and 0.007 in the development set and the validation set, respectively). However, the WBC, ALCs, and absolute neutrophil count in survivors and non-survivors were not significantly different on day 2 and day 4. Similar results were observed both in the development set and the validation set.

The association between day-3 ALCs and survival of cancer patients with sepsis was investigated by Kaplan-Meier analysis and log-rank test. The day-3 ALCs were classified into severe lymphopenia, moderate lymphopenia, and no lymphopenia. Statistically, severe lymphopenia and moderate lymphopenia significantly reduced 28-day (p = 0.002 and 0.007 in the development set and the validation set, successively) and 90-day (p = 0.001 and 0.002 in the development set and the validation set, consecutively) survival rate compared to no lymphopenia, both in the development and validation sets (Fig. 2 **and** Fig. 3).

Regarding the development set, univariate analysis demonstrated that APACHE II and SOFA scores, day-3 ALCs, and lactate levels were greatly related to 28-day mortality in cancer patients with sepsis (**Table 2**). Multivariate analysis, using the Cox proportional hazards model for all variables that were significant in the univariate analysis, indicated that the day-3 ALCs were an independent prognostic factor for 28-day mortality in cancer patients with sepsis. Similarly, for 90-day mortality, the day-3 ALCs were found to be an independent prognostic factor, with HR of 0.761 (95% CI: 0.625–0.927, p = 0.007). The validation set confirmed that the day-3 ALCs were the independent prognostic factor (p = 0.006) (**Table 2**).

	Univariate analysis		Multivariate analysis	
	HR (95% CI)	*p*-value	HR (95% CI)	*p*-value
Development set				
28-day mortality				
APACHE II score	1.088 (1.054–1.122)	<0.001	1.046 (1.009–1.085)	0.014
SOFA score	1.190 (1.115–1.269)	< 0.001	1.120 (1.042–1.204)	0.002
Lactate (mmol/L)	1.118 (1.083–1.153)	< 0.001	1.080 (1.041–1.120)	< 0.001
Day 3 ALC	0.628 (0.480–0.821)	0.001	0.743 (0.559–0.986)	0.04
90-day mortality				
APACHE II score	1.062 (1.036–1.088)	<0.001	1.033 (1.005–1.062)	0.021
SOFA score	1.109 (1.052–1.169)	< 0.001	1.055 (0.998–1.116)	0.06
Lactate (mmol/L)	1.116 (1.082–1.150)	< 0.001	1.087 (1.050–1.126)	< 0.001
Day 3 ALC	0.711 (0.588–0.861)	<0.001	0.761 (0.625–0.927)	0.007
Validation set				
28-day mortality				
APACHE II score	1.123 (1.041–1.212)	0.003	1.124 (1.026–1.230)	0.012
SOFA score	1.319 (1.149–1.513)	< 0.001	1.204 (1.046–1.387)	0.01
Lactate (mmol/L)	1.162 (1.075–1.257)	< 0.001	1.101 (1.017–1.192)	0.018
Day 3 ALC	0.344 (0.165–0.714)	0.004	0.431 (0.202–0.920)	0.03
90-day mortality				
APACHE II score	1.113 (1.043–1.187)	0.001	1.120 (1.040–1.206)	0.003
SOFA score	1.253 (1.109–1.415)	< 0.001	1.163 (1.028–1.316)	0.016
Lactate (mmol/L)	1.147 (1.062–1.238)	< 0.001	1.092 (1.011–1.180)	0.025
Day 3 ALC	0.360 (0.198–0.654)	0.001	0.417 (0.223–0.779)	0.006

Table 2

Table 2 The predictors of mortality in cancer patients with sepsis.

HR, Hazard ratio; CI, confidence interval. Abbreviations: see to Table 1.

The baseline characteristics are stratified by the day-3 ALCs (**Table 3**). For the development set, patients with severe lymphopenia had lower BMI, and higher APACHE II and SOFA scores. According to the validation set, patients with severe lymphopenia had higher lactate levels, higher SOFA score, and longer ICU length of stay.

Variables	No Lymphopenia	Moderate Lymphopenia	Severe Lymphopenia	*p*-value
Development set				
Number	64	98	78	
Age (years)	60.2±12.9	63.2±9.7	62.8±10.4	0.192
BMI (kg/m2)	23.4±3.0	22.7±3.0	21.9±3.8	0.02
Sex (male, %)	35 (54.7)	66 (67.3)	53 (67.9)	0.181
Body temperature (℃)	36.7 (36.4-37.0)	36.5 (36.4-37.0)	36.7 (36.4-37.0)	0.411
Respiratory rate (rate/min)	23 (20-32)	24 (18-29)	24 (16-32)	0.412
HR (bpm)	115±34	114±30	116±25	0.939
Lactate (mmol/L)	1.5 (1.0-2.9)	2.0 (1.1-4.4)	2.2 (1.3-5.0)	0.058
APACHE II score	17 (13-19)	17 (12-22)	18 (15-24)	0.012
SOFA score	7 (5-9)	8 (7-10)	9 (7-11)	< 0.001
Infection site of origin				
Lung	13 (20.3)	30 (30.6)	18 (23.1)	0.286
Abdomen	48 (75.0)	62 (63.3)	52 (66.7)	0.291
Other	3 (4.7)	6 (6.1)	8 (10.3)	0.389
Organism, n (%)				
Gram-positive	16 (25.0)	24 (24.5)	28 (35.9)	0.196
Gram-negative	41 (64.1)	53 (54.1)	39 (50.0)	0.231
Mixed	5 (7.8)	11 (11.2)	7 (9.0)	0.752
Fungal	2 (3.1)	5 (5.1)	9 (11.5)	0.098
Comorbidities, n (%)				
Coronary artery disease	10 (15.6)	10 (10.2)	9 (11.5)	0.576
COPD	0 (0)	0 (0)	1 (1.3)	0.352
Hypertension	13 (20.3)	12 (12.2)	14 (17.9)	0.351
Diabetes mellitus	10 (15.6)	8 (8.2)	5 (6.4)	0.147
Length of ICU stay, median (IQR)	3 (2-5)	4 (2-6)	3 (2-7)	0.601

Length of hospital stay, median(IQR)	28 (16-35)	22 (16-30)	20 (10-34)	0.152
ICU mortality (%)	9 (14.1)	11 (11.2)	18 (23.1)	0.091
Validation set				
Number	55	50	23	
Age (years)	66.3±11.2	66.9±9.0	68.1±10.2	0.778
BMI (kg/m2)	23.5±3.4	22.4±3.4	24.2±5.1	0.142
Sex (male, %)	34 (61.8)	37 (74.0)	18 (78.3)	0.241
Body temperature (℃)	36.7 (36.4-37.0)	36.8 (36.5-37.0)	36.8 (36.6-37.1)	0.201
Respiratory rate (rate/min)	16 (14-21)	17 (15-22)	15 (14-21)	0.744
HR (bpm)	99±30	92±28	101±28	0.385
Lactate (mmol/L)	1.9 (1.3-3.2)	1.9 (1.3-2.6)	3.0 (1.3-6.2)	0.048
APACHE II score	26 (23-28)	25 (23-27)	27 (24-29)	0.324
SOFA score	7 (5-8)	7 (6-8)	9 (7-10)	0.004
Infection site of origin				
Lung	18 (32.7)	14 (28.0)	9 (39.1)	0.632
Abdomen	37 (67.3)	34 (68.0)	14 (60.9)	0.822
Other	0 (0)	2 (4.0)	0 (0)	0.25
Organism, n (%)				
Gram-positive	16 (29.1)	12 (24.0)	3 (13.0)	0.32
Gram-negative	27 (49.1)	27 (54.0)	15 (65.2)	0.428
Mixed	5 (9.1)	7 (14.0)	3 (13.0)	0.72
Fungal	7 (12.7)	4 (8.0)	2 (8.7)	0.702
Comorbidities, n (%)				
Coronary artery disease	13 (23.6)	13 (26.0)	4 (17.4)	0.722
COPD	3 (5.5)	1 (2.0)	1 (4.3)	0.655
Hypertension	15 (27.3)	12 (24.0)	4 (17.4)	0.649
Diabetes mellitus	8 (14.5)	7 (14.0)	3 (13.0)	0.985

Length of ICU stay, median (IQR)	1 (1-3)	3 (1-5)	3 (2-5)	0.001
Length of hospital stay, median(IQR)	21 (16-28)	24 (18-33)	21 (17-31)	0.533
ICU mortality (%)	4 (7.3)	2 (4.0)	4 (17.4)	0.138

Table 3
Table 3 Characteristics of patients stratified by day 3 absolute lymphocyte count.

Data are expressed as means (SD) or percentage. SD, standard deviation; BMI, body mass index; COPD, chronic obstructive pulmonary disease; HR, heart rate; ICU, Intensive Care Unit; SOFA, Sepsis Related Organ Failure Assessment; APACHE, Acute Physiology and Chronic Health Evaluation; IQR, 25%, 75% interquartile range.

Discussion

The present findings were consistently found and evidently confirmed in two hospitals. The results suggested that the day-3 ALCs might be an independent prognostic factor for both 28-day mortality and 90-day mortality in cancer patients with sepsis. Both lymphocyte apoptosis and recruit of peripheral lymphocytes to the areas of inflammation are important reasons for lymphopenia in sepsis[10, 20]. ALCs usually decrease to similar levels in survivors and non-survivors in the early stages of sepsis; however, it experiences lymphocyte recovery in survivors, while that of non-survivors remains low[21]. Previous studies showed that lymphopenia is effective for the early diagnosis of sepsis and indicates a higher mortality[22]. Additionally, ALCs after esophagectomy decreased more than that after colorectal cancer surgery, whilst lymphopenia did not occur after minor surgical procedures[23, 24]. More postoperative lymphopenia was seen in patients after the open surgery than those after laparoscopy[23]. Furthermore, lymphopenia on the day 4 after the diagnosis of sepsis was independently associated with high 28-day mortality in sepsis patients[10]. Nevertheless, the present findings revealed that the prognosis of cancer patients with postoperative sepsis was correlated with the day-3 lymphopenia. Obviously, our findings were consistent with previous studies. It seems that ALCs decline more rapidly in cancer patients with postoperative sepsis, compared to the sepsis patients without cancer and lymphopenia might be a predictor in cancer patients with postoperative sepsis.

At the early stage of sepsis, strong systemic inflammatory response stimulates the increase of anti-inflammatory response and leads to the negative regulation of lymphocytes [21, 25, 26]. Immune exhaustion occurs in both cancer and sepsis, while tumor cells expressing pro-apoptotic ligands could induce the destruction of lymphocyte, which might lead to different outcomes between cancer-related and non-cancer-related sepsis[27–30]. Apoptosis affects lymphopenia in postoperative sepsis in cancer by both extrinsic and intrinsic pathways[27]. The extrinsic pathway activates caspase-8 with the binding of inducers of cell surface receptors[27]. The intrinsic pathway, also known as “mitochondrial” pathway, is an activator of caspase-9, and the products of pro- and anti-apoptotic genes of the Bcl-2 superfamily lost

balance in this pathway[27]. Then, both pathways lead to caspase-3 activation and DNA fragmentation[27]. Thus, apoptosis may play a major role in the mechanisms of the present findings.

There are some strengths in our study. It is the first study to demonstrate the prognostic value of lymphopenia in cancer patients with postoperative sepsis. ALCs primarily reflect the infection and systemic inflammatory response syndrome state and it has some significant characteristics, including low economic cost, rapid detection, global acceptance, and easy interpretation. However, several limitations need to be considered. Several limitations might be taken into consideration. Firstly, it was the retrospective study, so the prospective studies are required to reduce the selection bias. Secondly, the present data did not provide evidence on the mechanistic explanation; as a consequence, further studies should be conducted to explore the potential mechanisms. Thirdly, this study only included Chinese participants; therefore, the findings may not be applied to other ethnic groups. Further studies are warranted to clarify the role of the lymphocyte subsets in cancer patients with sepsis.

Conclusion

In accordance with the day-4 lymphopenia prediction of sepsis diagnosis, this present study revealed that lymphopenia on the day 3 after the diagnosis of sepsis was able to predict the early mortality in postoperative cancer patients. The present findings provided a new insight into the pathobiology of sepsis and suggested possible therapeutic targets for the management. Cancer patients with lymphopenia in postoperative sepsis may need more active follow-up and treatment than general sepsis patients.

Abbreviations

ALCs, absolute lymphocyte counts

APACHE, Acute Physiology and Chronic Health Evaluation

BMI, body mass index

CEA, carcinoembryonic antigen

CVs, coefficients of variation

COPD, chronic obstructive pulmonary disease

HIV, human immunodeficiency virus

HR, heart rate

ICU, Intensive Care Unit

SOFA, Sepsis Related Organ Failure Assessment

WBCs, white blood cells

Declarations

Ethics approval and consent to participate

Written informed consents were obtained from all patients. This study was approved by the Institutional Review Board of the Harbin Medical University Cancer Hospital and the Affiliated Second Hospital of Harbin Medical University.

Consent for publication

Not applicable

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests

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Authors' contributions

JY L was a major contributor in visualization, methodology, and writing-original draft preparation.

YX Liu analyzed and interpreted the patients' data. ML Z and WJ H were contributors in data curation, visualization, and investigation. YH P contribute to follow-up. RT W and KJ Y contribute to conceptualization, writing- reviewing, and supervision.

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Figures

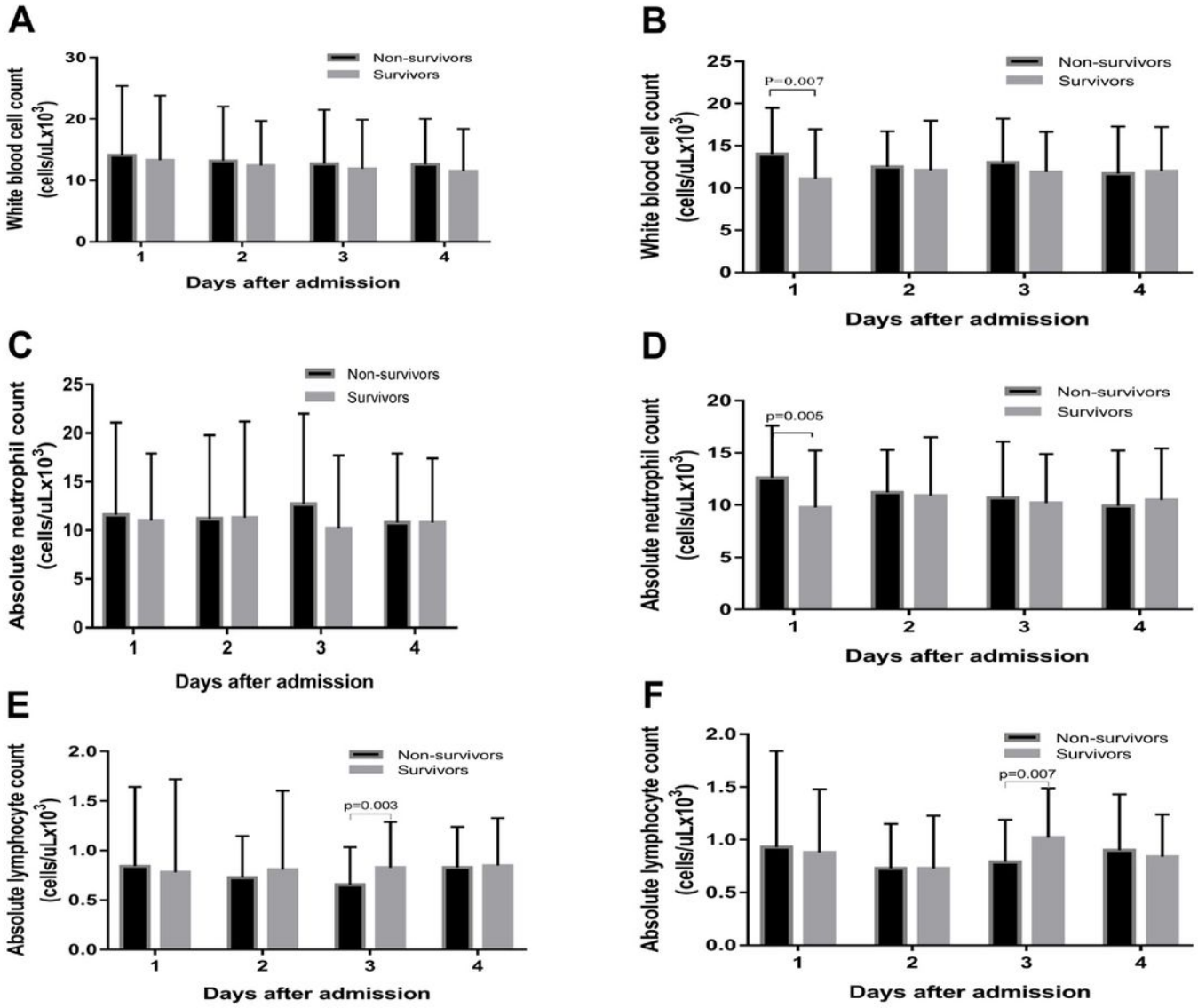

Figure 1

White blood cell, absolute lymphocyte count, and absolute neutrophil count in survivors and non-survivors during the first four days following sepsis diagnosis.

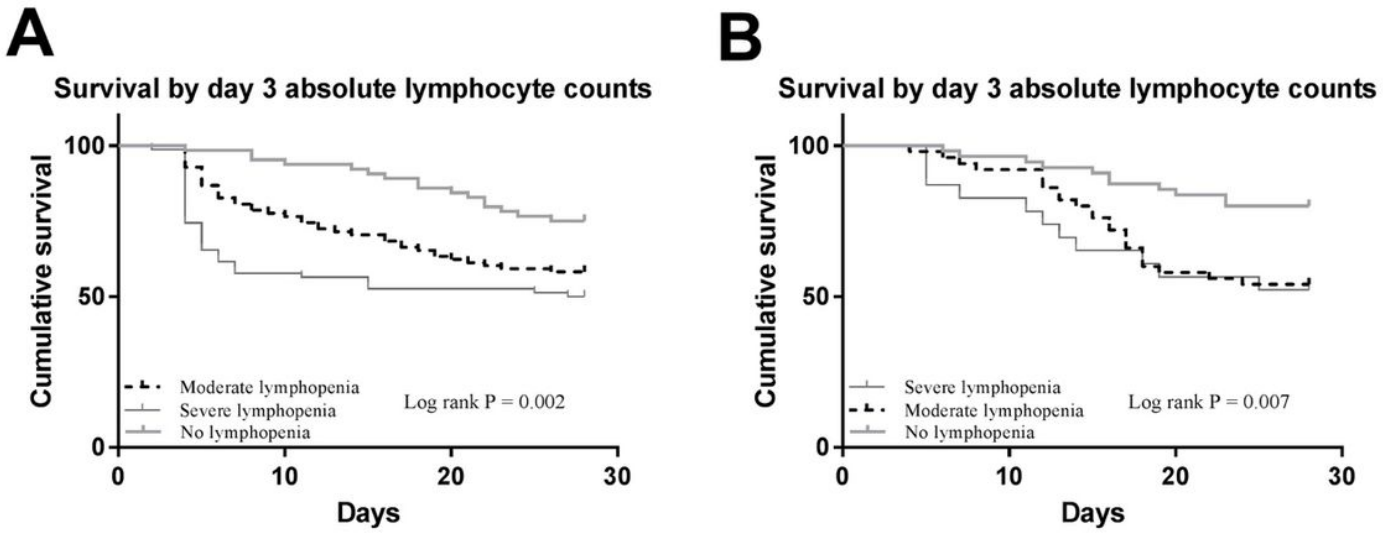

Figure 2

Kaplan-Meier analysis of survival time up to 28 days after ICU admission according to the day-3 absolute lymphocyte counts.

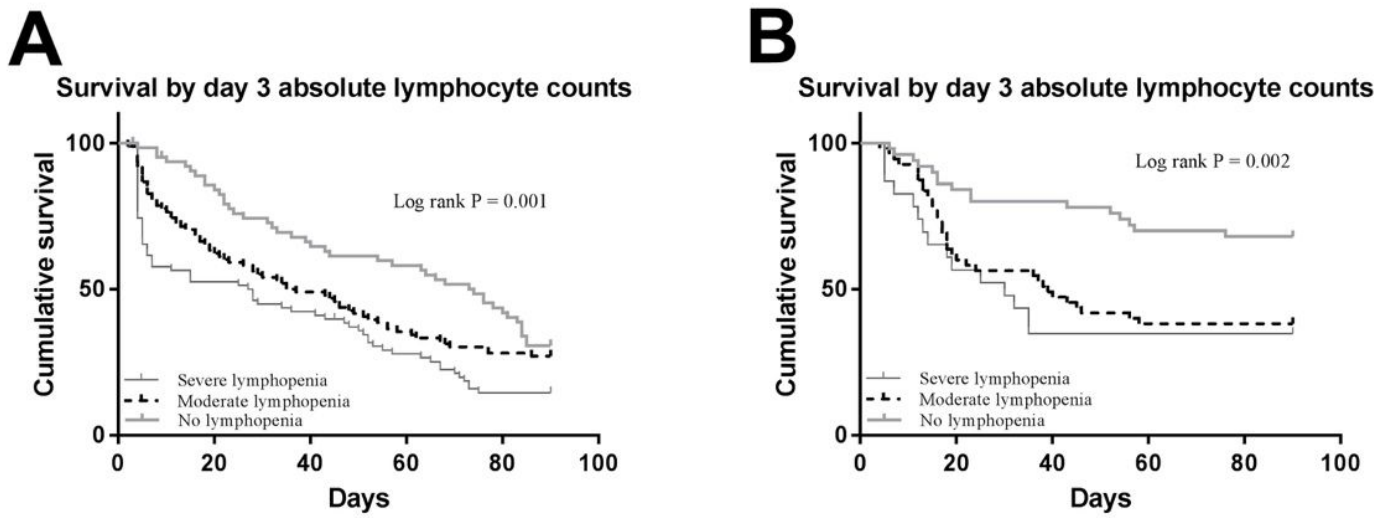

Figure 3

Kaplan-Meier analysis of survival time up to 90 days after ICU admission according to the day-3 absolute lymphocyte counts.